Properties of Metallized Film in a Free Span Web Metallizer

F. Casey, N.A.G. Ahmed and G. Ellis, General Vacuum Equipment Ltd., United Kingdom

Key Words: Aluminium; Equipment design & construction; Web coating; Oxygen permeation (metal coating)

ABSTRACT

Conventionally metallizing of packaging films and papers has taken place with the substrate supported off a chilled drum. Metallizing onto a web "free span" where the substrate is unsupported gives different coating characteristics. The present paper discusses these results and the substrates on which these coating characteristics can be used to advantage.

INTRODUCTION

Free span metallizers were first built in the 1970's and run film satisfactorily. We built the first free span machine in 1988 and since then have built another eight. The first of these machines was for board and paper. Cooling is not important for these materials as the retained water in the substrate evaporates to maintain an even temperature. Compared with film very little contact cooling is required. Interest developed for film metallizing with respect to cast polypropylene and low density polyethylene. Neither of these materials could withstand the high tension necessary to eliminate the wrinkles on the drum. As these films are not heat sensitive they are ideal for free span metallizing where wrinkling and subsequent defects in the metallized film are eliminated.

ADVANTAGES - FREE SPAN METALLIZING

Increase in source efficiency.
No drum to clean.
No edge shields to clean or adjust.
Edge to edge metallizing.
Alignment of unwind not critical.
Some edge movement of film is allowable.

DOWNSIDE - FREE SPAN METALLIZING

Film gets hotter.
Not suitable for all film.
Unsuitable for thin films.
Films are getting thinner.

Recent substantially improved film cooling on the drum machine resulting in easier removal of wrinkling from the drum has largely taken away the main advantage of the free span machine with respect to most films. [1, 2]

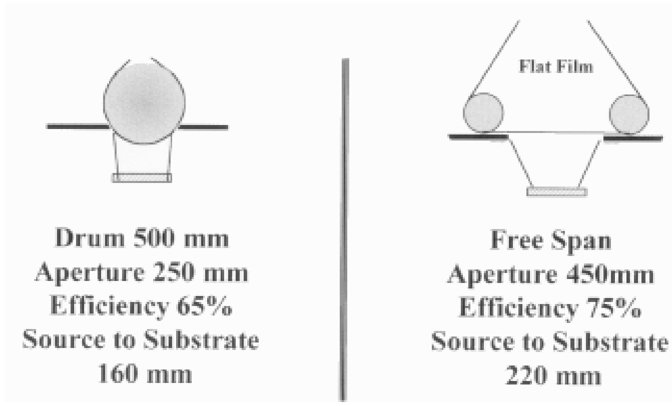


Figure 1. Comparison: Drum—Free Span.

Figure 1 shows a typical relationship between a free span and a drum machine. The aperture on a drum machine is limited by the size of the drum. A 500 mm drum gives an aperture of 250mm. Bringing the source as near as possible to the drum gives a maximum collection efficiency of 65%.

With the free span machine there is a wider aperture. The boats can also be moved farther from the film to reduce radiant heat that is proportional to d^2T^4. Also with this arrangement the evaporant arrives at a more normal angle to the substrate. 75% collection efficiency can be achieved.

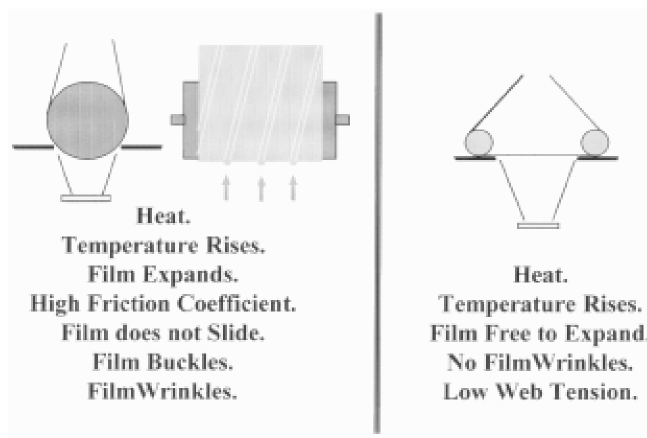


Figure 2. Wrinkling.

42nd Annual Technical Conference Proceedings (1999) ISSN 0737-5921

During metallization the heat input to the film raises the temperature causing expansion. (Figure 2). On a drum machine under vacuum high friction between the film and the drum prevents the film expanding easily. As a result the film buckles on the drum causing wrinkles. With a free span machine the film is free to expand. A smooth surface is presented to the evaporant and no defects occur. As mentioned earlier, improvements in film cooling on a drum machine have leveled up to some extent this advantage.

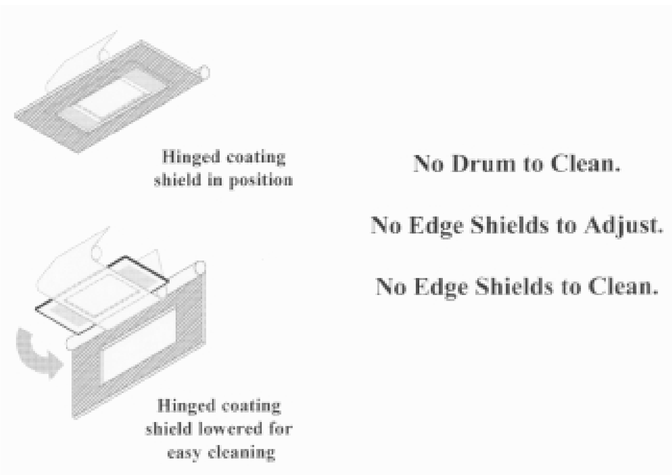


Figure 3. Easy Cleaning.

The shielding around the aperture where the aluminium is applied to the substrate is simple. (Figure 3.) The hinged shield can be lowered for easy cleaning and for accessibility to the plate behind the web. There are no edge shields to adjust or clean. As there is no drum there is no drum to clean.

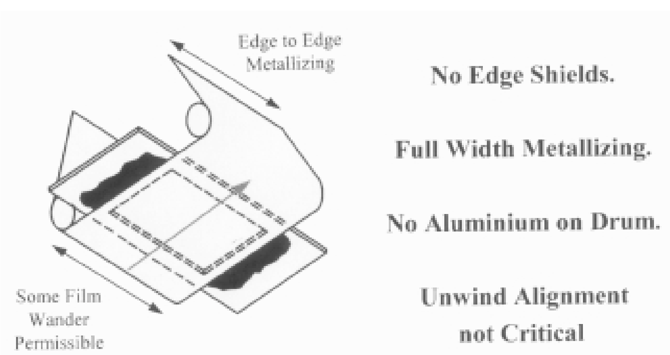


Figure 4. Edge to Edge Metallizing.

Because there are no edge shields edge to edge metallizing is possible, alignment of the unwind is not critical and some film wander is permissible. (Figure 4).

Another advantage claimed [3] for free span is, because of the large thermal gradient between the cooled process drum and the hot film surface, micro-cracking in the aluminium layer can occur on a drum machine, resulting in reduced barrier.

EXPERIMENTAL WORK

Comparison tests were carried out with film metallized in a drum and a free span machines. The film was metallized at various optical densities. The coating structures and the barrier performances of the resulting metallized films were then examined. The BOPP film used was supplied by Hoechst (Trespaphan SCM17, 17.5 micron thick). The film was reverse sided heat sealable grade. Neither the drum machine nor the free machine affected the heat sealability of the film. Figure 5 shows a schematic diagram of the free span metallizer. In the present work all films were metallized at various optical densities. A film speed of 8m/s was chosen so as to conserve material.

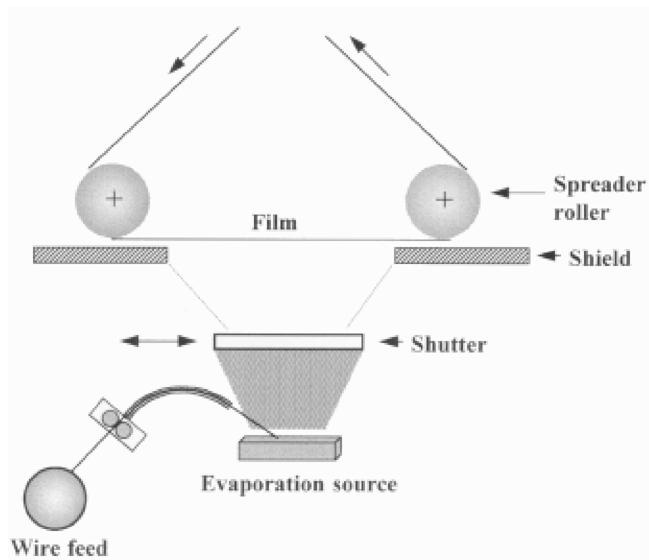
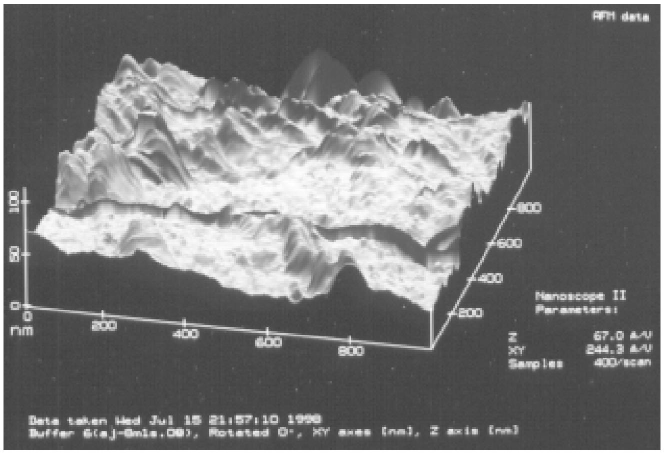


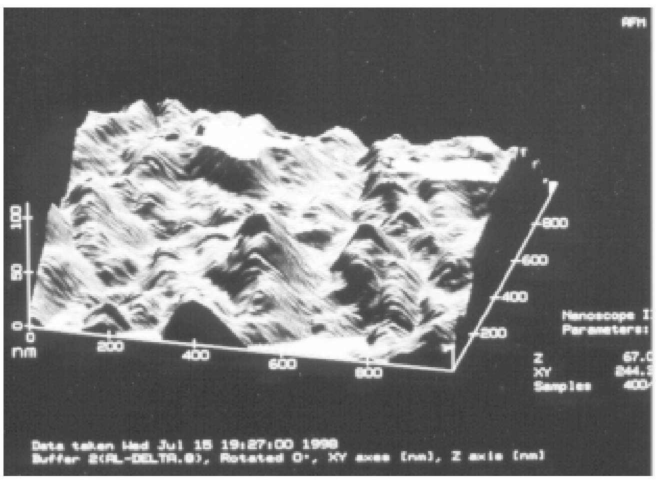
Figure 5. Schematic Diagram of Free Span Metallizer.

RESULTS

The reverse sides of the films were tested using a high magnification optical microscope. The investigation shows no evidence of any aluminium deposit on the reverse side of film metallized with a free span machine. A further test was carried out to etch and remove aluminium from the metallized sides to inspect the reverse sides of films. In this test a dilute solution of sodium hydroxide was used to etch the aluminium. Again, there is no evidence of any aluminium deposit on the reverse side of free span metallized film. The heat sealability quality of the free span metallized film was equal to the quality of the drum metallized film.



Figures 6. AFM Photograph of coating Structure: Drum.



Figures 7. AFM Photograph of coating Structure: Free Span.

The structure of the aluminium on film produced on a free span machine and a drum machine was analysed using AFM microscopy. Figures 6 and 7 shows such a comparison. The structure of aluminium metallized in a drum machine shows a typical columnar growth. The structure of aluminium metallized in a free span machine exhibits a slightly more dense structure probably due to the higher substrate temperature. This is illustrated in Figure 8.

A micro-crack can be seen in the photograph related to drum metallizing. However, there is no evidence of any loss of barrier in the tests undertaken on the drum metallized film. Calculation of substrate temperature indicates that at a film speed of 8m/s the substrate temperature during metallization in a drum machine is below 60°C while the substrate temperature during metallization in a free span machine is 80°C or higher. High substrate temperature affects the nucleation sites of depositing atoms and can result in a molten structure instead of columnar growth [4]. Such a structure could affect the barrier properties of the metallized film.

A comparison between the barrier properties of films metallized in a free span and drum machines was carried out. The results are shown in table I.

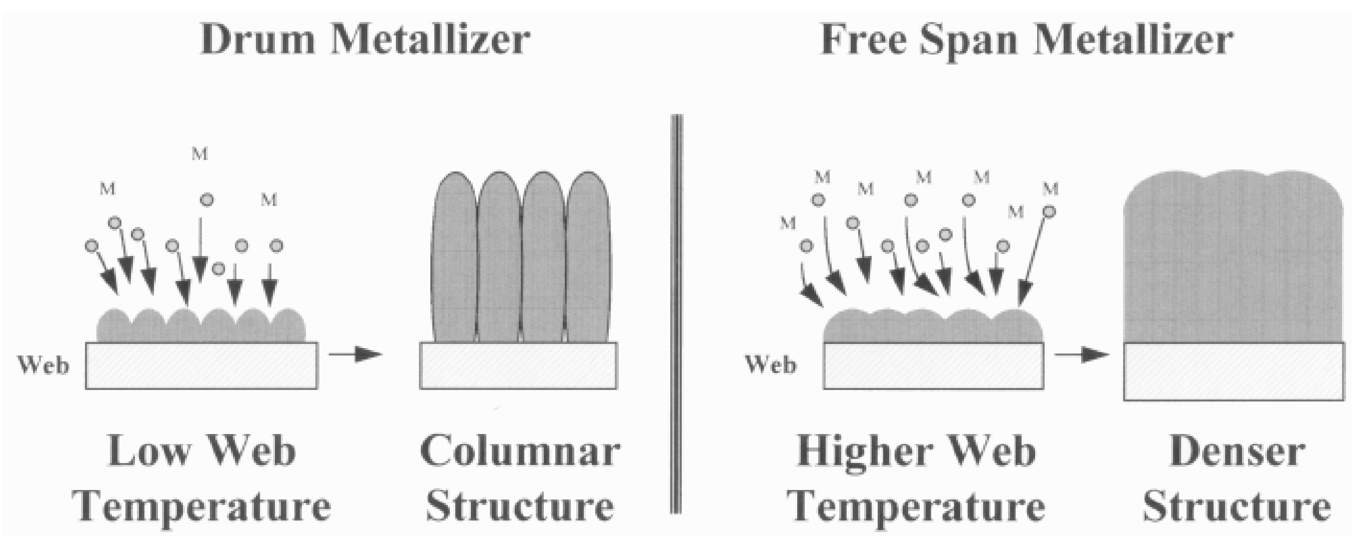


Figure 8. Coating Structure: Drum and Free Span.

Table I. Barrier Test Results: Drum and Free Span.

Metallizer Type	Nominal Optical Density	WVTR ASTM E96 g/m^2 day	OTR ASTM 1434 cc/m^2.day
Drum	2.1	0.37	60
Drum	2.35	0.27	48
Drum	2.75	0.23	45
Free Span	1.5	0.49	63
Free Span	2.35	0.28	50
Free Span	2.75	0.3	47

From this table it is clear that there is no noticeable difference in barrier properties between metallized BOPP films in drum and free span machines. Also, the data reinforce the known concept that lower optical density of 1.5 and 2.1 OD gives poorer barrier properties. On the other hand, the optical density of 2.75 compared to 2.35 has a marginal effect on barrier properties. Therefore, films metallized with both machines show near identical barrier performance of a very good standard.

Plasma pre-treatment of film on a free span machine gives the same benefits of improved barrier performance and lower sheet electrical resistance as for a drum machine [5].

CONCLUSION

Our investigations have shown that metallizing onto a web "free span" where the substrate is unsupported gives the same barrier properties to film metallized in a standard drum machine. However, there is some difference in the structure of aluminium coating due to higher substrate temperature in free span metallization.

REFERENCES

1. European Patent Application EP 0311 302 A1. September 29, 1988.

2. UK Patent Application 2326647. June 25, 1997.

3. A. Yializis, R.E. Ellwanger and J. Harvey, "Barrier Degradation in Aluminium Metallized Polypropylene Films," Society of Vacuum Coaters, 40th Annual Technical Conference, 371 (1997).

4. N.A.G.Ahmed, *Ion Plating Technology, Development and Applications,* p. 97, John Wiley & Sons (1987).

5. A. Smith, Internal Document. Not Published.